ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Seventh Quarterly Progress Report
For the Period
January 1 through March 31, 1964

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-81

Placed by
Industrial Preparedness Directorate
United States Army Electronics
Materiel Agency

AEROPROJECTS INCORPORATED
West Chester, Pennsylvania

ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

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The object of this program is to design and construct prototype welding equipments and their associated accessories to perform by ultrasonic techniques the welding operations required in the assembly of electron tubes under Specifications SCS-114A and SCIPPR-15.

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Report Prepared by: J. G. Thomas

Report Approved by: Byron Jones

ABSTRACT

Ultrasonic welding of the Type 6080WB electron-tube mount was reviewed by Tung-Sol representatives, and details are presented. The use of ultrasonic energy in the successful assembling of electron-tube components with interference fits is described.

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PURPOSES

The objectives of this Production Engineering Measure (PEM) are to:

1. Demonstrate the capability limits of ultrasonic welding to join combinations of metallic materials of interest to the electron-tube industry. Devote major effort to making satisfactory joints in materials and geometries which might be difficult or impossible to join by other means.

2. Analyze the welding requirements for three specific electron tubes. The three tube types selected are the Type 6080WB, 5814WB and 6205. These were selected by the U. S. Army Electronics Command because they are widely used in military equipment, and have a record of failures due to improperly welded joints.

3. Prepare fixturing and tooling for the specific electron tubes, so that ultrasonic welding may be used in the manufacturing process.

4. Ultrasonically weld the parts required to assemble electron-tube mounts for the three tube types, and compare results obtained against similar sub-assemblies made by conventional joining methods. Tests will include strength and environmental tests.

5. Build production ultrasonic welding equipment which will enable an electron-tube manufacturer to make the welded connections in a broad range of electron-tube types.

6. Install the ultrasonic welding equipment in a production company, and produce on a pilot basis with that company's personnel, a limited lot sise of each of the three tubes for subsequent evaluation in accordance with applicable military specifications.

NARRATIVE AND DATA

Messrs. B. F. Steiger and Norman Helmstetter of Tung-Sol Electric Inc.* visited Aeroprojects on January 8, 1964 to evaluate the ultrasonic welding and assembly sequences of the Type 6080WB electron-tube mount. Using tooling and welding procedures described in the Sixth Quarterly Progress Report, a complete electron-tube mount was assembled and welded on the "Sonoweld" ultrasonic welder, Model W-600-TSR. The Tung-Sol representatives expressed satisfaction with the quality of the welds, the ease with which they were effected, the simplicity of tool change, and the absence of spatter and oxidation resulting from the welding.

As discussed in the Sixth Quarterly Report, the glass had fractured in glass stem assemblies during the welding of connectors and stem leads. This problem had been solved satisfactorily by crimping of the stem leads prior to welding. Prior experience in welding leads of glass-metal assemblies indicated that the temper of the glass material had an affect on the ability to make satisfactory joints on the lead portion of the assembly without destroying the quality of the seal. It therefore seemed advisable to investigate the possible effect of several tempers of glass in the stem assemblies.

Accordingly, Tung-Sol supplied stem assemblies in three heat-treat conditions, designated in their terminology as neutral, low-compressive residual stress, and high-compressive residual stress. The low-compression temper is normally used in the production of the Type 6080WB electron-tube mount. The assemblies had 1-inch projections of wires past the glass seal, sufficiently long to permit forming and trimming into final prescribed length.

Ultrasonic welds were made between the connectors and the stem leads at the extremities of these wires in each temper of glass. Fracturing did not occur. Welds were then made progressively toward the glass seal. Each temper of glass fractured at approximately the same distance from the feed-through seal section as in the original production assemblies. Results of this work are tabulated in Figure 1. Since it appeared that the condition of the glass (temper) was not a contributing factor in fracturing, the stem lead extensions were crimped in the manner described in the Sixth Quarterly Progress Report, and satisfactory welds were made at any desired distance from the glass seal past the crimped area without breakage in each of the three types of glass condition.

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* Functions of Chatham Electronics Division of Tung-Sol Electric Inc. as applied to this contract have been changed to Tung-Sol Electric Inc., Electron Tube Division.

Observation by Tung-Sol representatives indicated that some auxiliary steps in fixturing may assist the ultrasonic welder operator in locating components. Since these are uncomplicated, they can readily be added by Tung-Sol after receipt by them of the equipment and tooling. It was further observed that anvil tip A2 (Figure 4, Sixth Report) did not provide component clearance adequate for operator freedom and for avoidance of possible parts distortion during welding. As a result, an alternate anvil tip was designed, constructed, and tested. The modified tip is shown in Figure 2, along with the original anvil tip. Test welds performed with the new tip were of the same satisfactory quality as those obtained with the original design.

The carbon anodes of the Type 6080WB electron-tube mount broke frequently during the insertion or removal of the anode support rods. Anode breakage usually accounts for 25-65 percent of the total rejects during tube manufacture. These rods are 0.062-inch diameter nickel, forced into holes through the carbon anodes with an interference fit. It has been repeatedly demonstrated in the Aeroprojects' laboratories (unpublished) that vibratory energy is effective in reducing friction between contacting metal surfaces. Metal components such as concentric tubes with close-tolerance and even interference fits have been successfully assembled utilising ultrasonic activation. Forces are reduced, as is the scoring of mating surfaces. This concept was applied to the assembly of anode support rods into the carbon anodes. A Sonobond Corporation "Sonosolder" Model S-O-HN (12-watt) ultrasonic tip was used as shown in Figure 3. A hole approximately equal to the diameter of the anode support rod was drilled in the end of the "Sonosolder" tip, and the rod was inserted therein (Figure 3A). Ultrasonic energy was applied, and the rod was inserted into the carbon anode as shown in Figure 3B. Very little force was required to successfully assemble the two parts. The problem of carbon anode breakage was eliminated.

Carbon anodes for the 6080WB electron tube are usually salvaged from otherwise defective tubes and reused because of their high cost relative to other tube components. Anode breakage frequently occurs during removal of the support rod. Attachment of the anode support rod to the ultrasonic unit can be accomplished by the use of a collet, or a clamping mechanism tightened by a set screw. This ultrasonic technique should allow the manufacturer to use lower tolerances in production of parts. Furthermore, the method is easily adaptable to production operations, and lends itself to multiple rod insertions simultaneously by appropriate fixturing.

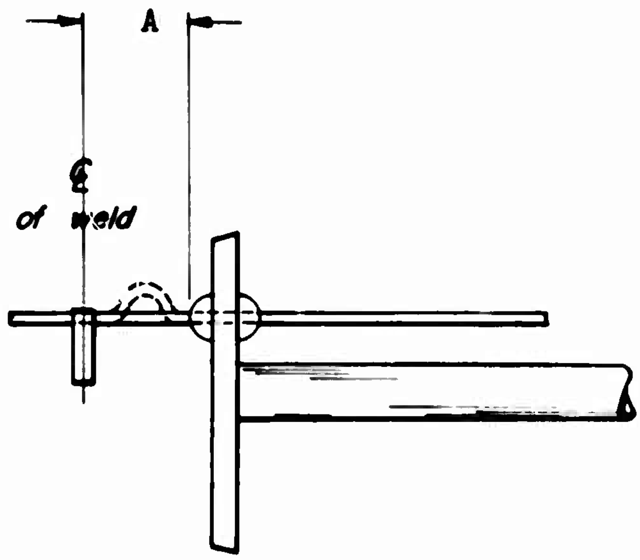
It was also noted that the Alsimag (white) ceramic spacer components were considerably more fragile and subject to breakage during assembly than the Photoceram (blue) spacers. Since the Alsimag spacers are normally used in the production of the Type 6080WB electron-tube mounts, they will continue to be used in this program. Breakage occurred only in those cases where the grid wires were forced into the spacer holes, prestressing the ceramic spacer. Fracture was induced by allowing the spacer to contact the active sonotrode in this prestressed condition. Breakage was eliminated by selecting component parts of good fit and protecting the ceramic spacer from accidental contact with the sonotrode. A rubber "bumper" affixed to the sonotrode achieved this result.

CONCLUSIONS

Work on the program has been completed pending approval by the USAECOM for the change in engineering effort which will be explained in the next report.

PROGRAM FOR NEXT REPORTING PERIOD

Approval by the USAECOM on the engineering effort modifications is expected at the beginning of the next report period. Under this revised program, some further tooling will be provided for welding the electron tube Type 6080WB and the equipment will be sent to Tung-Sol for production set up. The application of ultrasonic welding to the manufacture of molybdenum frame grids will be evaluated. The ultrasonic welding of 0.003-inch diameter tungsten-rhenium wire to tungsten, molybdenum, and nickel sheet will be investigated and evaluated.



GLASS CONDITION	A
Neutral	7/16 inch
Low-compression temper	7/16 inch
High-compression temper	1/2 inch

Figure 1

PARTIAL SCHEMATIC OF GLASS STEM ASSEMBLY SHOWING AREA OF STEM LEAD EXTENSION IN WHICH ULTRASONIC WELD CAUSED GLASS FRACTURE. (Problem Resolved By Crimping)

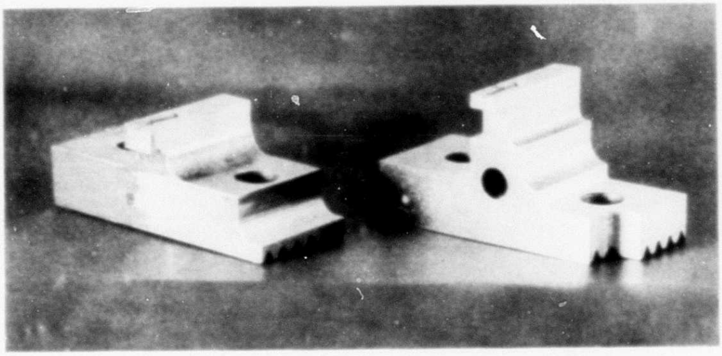
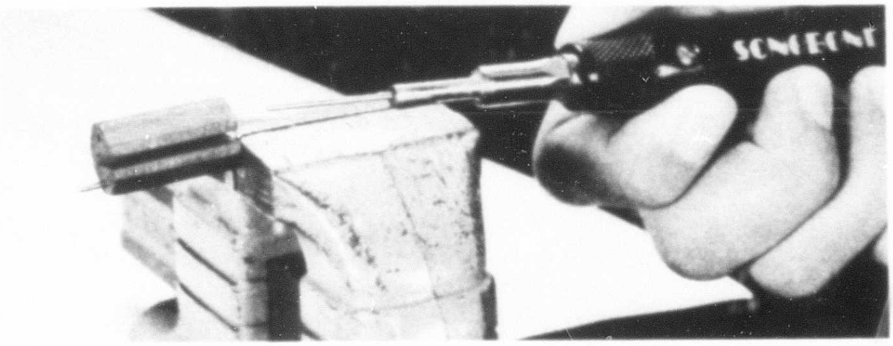


Figure 2

MODIFIED ANVIL TIP A2 USED IN WELDING
GRID AND ANODE EYELETS AND CONNECTORS

Modified anvil tip A2 at right shows redesign to afford greater component clearance. Anvil tip at left is original design, reported in the Sixth Quarterly Progress Report. Welds made with the modified anvil tip were of the same satisfactory quality as those originally obtained.



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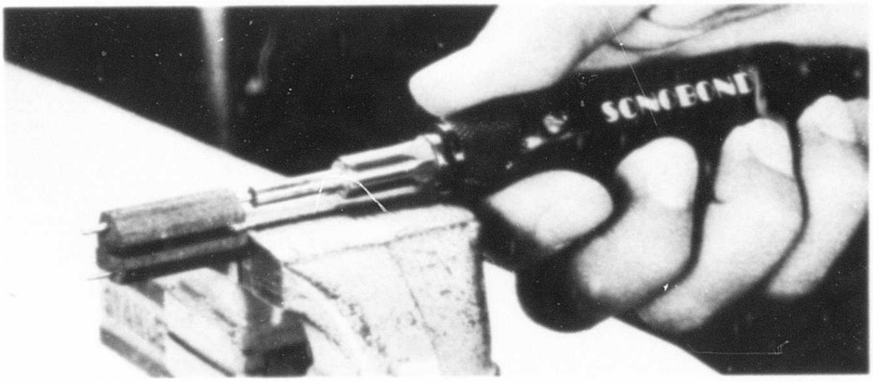

B

Figure 3

INSERTION TECHNIQUE USED IN ASSEMBLING
ANODE SUPPORT ROD INTO CARBON ANODE

Photograph A shows anode support rod inserted into a drilled Sonobond Corporation "Sonosolder" Model S-O-HN (12-watt) ultrasonic tip. Photograph B shows the rod fully inserted into the carbon anode after application of ultrasonic energy.

VISITS DURING THIS REPORT PERIOD

Date	Visit	Purpose
1/8/64	Messers. B. F. Steiger and N. Helmstetter, Chatham Electronics, Bloomfield, New Jersey, visited Aeroprojects, West Chester, Pennsylvania	Observe assembly sequence and ultrasonic welding of junctions in the Type 6080WB electron-tube mount.
1/22/64	W. N. Rosenberg visited Mr. H. Shienbloom, U. S. Army Electronics Command, 225 South Eighteenth Street, Philadelphia, Pennsylvania	Review Progress Report drafts.
2/20/64	Messers. T. Kyne, H. Shienbloom and C. Mogavero, USAECOM, visited Aeroprojects, West Chester, Pennsylvania	Inspect ultrasonic welding equipment and tooling procured under this contract, and observe equipment making typical junctions for the electron-tube industry.

TECHNICAL MAN-HOURS

EXPENDED DURING THIS REPORT PERIOD

Name	Project Position	Hours Expended This Report Period
W. N. Rosenberg	Project Supervisor	23
J. G. Thomas	Metallurgist	37
W. B. Devine	Director of Publications	20
N. Maropis	Physicist	2-1/2
	Total	82-1/2

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